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COOPERATIVE SPECTRUM SHARING IN COGNITIVE RADIO NETWORKS WITH UPPER CONFIDENCE BOUNDS

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ABSTRACT

According to Federal Communication Commission (FCC), more than 70% of the available spectrum is not utilized optimally. Cognitive radio is a better technique to fulfill the utilization of radio frequency spectrum. We consider the problem of cooperative spectrum sharing among a primary user and multiple secondary users, where the primary user selects a proper set of secondary users to serve as the cooperative relays for its transmission. Most previous works are focused on developing complex algorithms which may not be fast enough for real-time variations such as channel availability and/or assume perfect information about the network. Instead, we develop a learning mechanism for a PU to enable CSS in a strongly incomplete information scenario with low computational overhead. Our mechanism is based on a Distributed Algorithm, enhanced with the concept of Upper Confidence Bound (UCB). This algorithm can be extended to include more sophisticated features while maintaining its desirable properties such as low computational overhead and fast speed of convergence.

KEYWORDS- cooperative spectrum sharing, Distributed Algorithm, low computational overhead, speed of convergence, utilization

I. INTRODUCTION

Owning to the ever-growing spectrum demand by the recent wireless technologies as well as the inefficiency of traditional static spectrum assignment policy, spectrum scarcity has become a critical challenge in wireless communication networks. Studies show that the traditional static spectrum assignment policy is highly inefficient observing the fact that the allocated bandwidths remain unused by the licensed users, for a considerable amount of time. Indeed, the spectrum utilization can vary in the range of 15% to 85% depending on the geographical distribution and time. Dynamic spectrum sharing is seen as a promising approach toward alleviating spectrum scarcity in wireless networks. It allows the unlicensed or secondary users (SUs) to dynamically access the licensed bands of the legitimate primary users (PUs) in exchange for functional or pecuniary compensation. Generally, there are two scenarios of dynamic spectrum sharing in literature based on the primary users' awareness of the secondary network's presence, namely common model and property-rights model. In the common model, the primary users are oblivious to the secondary network's presence and behave as if there is no secondary activities. The secondary users sense the radio environment in search for spectrum holes and then exploit it in an opportunistic manner. In the property-rights model, it is assumed that the primary users are aware of the secondary network's presence and are willing to lease a portion of their spectrum in exchange for monetary or functional compensations. While the cooperative spectrum sharing carries considerable potential advantages in terms of spectral efficiency, its deployment in wireless networks involves several new technical challenges including interference management, designing incentive-based protocols to encourage the cooperation selecting the optimal cooperative partner for the nodes, as well as distributed self-organization among the others.

II. RELATED WORKS

Many previous works on CSS provide a framework to exploit dependencies among arms in multi-armed bandit problems, when the dependencies are in the form of a generative model on clusters of arms. They find an optimal MDP-based policy for the discounted reward case, and also give an approximation of it with formal error guarantee [1]. Spectrum pooling in cognitive radio systems is an approach to manage

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the available spectrum bands from different licensed networks. Most previous work on spectrum pooling concentrates on the system architecture and the design of flexible-access algorithms and schemes. In this paper, a cooperative scheme for internetwork spectrum sharing among multiple secondary systems is presented, which takes into account the price and spectrum efficiency as the design criteria [2]. The rapid growth of wireless systems have led to increased demand of the spectrum in the wireless services. The dynamic allocation of the wireless channel is one of the viable options which offer a great deal of scope to overcome several challenges. Cognitive Radio (CR) technology offers likelihood of dynamic allocation of spectrum by enabling unlicensed users to use the licensed spectrum in a proficient manner through dynamic spectrum access[3].

A spectrum leasing system in which secondary networks offer offload services to a primary network (PN) in exchange for temporary access to the PN's spectrum. When the coverage areas of several secondary access nodes (SANs) overlap, they compete for primary users (PUs), which benefits the PN, except when the SANs collude and coordinate their prices, forming a cartel[4]. In Existing system, the dynamic spectrum access (DSA) policies have been designed. DSA allows unlicensed secondary users (SUs) to opportunistically access the spectrum, sparsely used by the primary users (PUs). This spectrum trading has the advantage to provide primary users with incentives to allow access to their resources. While SU may act as transmission relays for a PU. The existing work is in the framework of Cooperative Spectrum Sharing (CSS), also known as Cooperative Secondary Spectrum Access (CSSA). The CSS is particularly useful when the PU's own demands are so high that it would rarely have spectrum to lease. Here a loss in transmission efficiency is pointed out. CSS mechanism design poses the following key challenges:

- It allocates resources for spectrum.
- The SUs differs from the PU's because of self-interested networks.With SUs, the PU has to undergo a negotiation process having no previous specific information about them. The situation around the PU can change quickly.
- Spectrum opportunities can happen on a short timescale, this negotiation must be carried out in real time.

They have proposed a spectrum trading mechanism in Cooperative Spectrum Sharing (CSS) allowing a primary transmitter (PT) to learn its most profitable action. It is based on a nested scheme, and is capable of handling an intractable problem, making use of Multi-Armed Bandits (MABs). They developed two algorithms, MAB-MDP and Super-UCB. These algorithms can payoff maximizing actions for the primary transmitters with little communication.

III. COOPERATIVE SPECTRUM SHARING

Cooperative spectrum sharing is also called as the collaborative spectrum sharing. It considers the effect of the node's communication on other nodes, in this case the interference measurements of each and every node shared among the other nodes. All the centralized spectrum sharing solutions are considered as the cooperative spectrum sharing. Cooperative Spectrum Sharing (CSS) is an appealing approach for primary users (PUs) to share spectrum with secondary users (SUs) because it increases the transmission range or rate of the PUs. In a cooperative cognitive radio network, the primary users lease their spectrum to secondary users for a fraction of time and in exchange, they get the cooperative transmission power from the secondary users. We consider the problem of cooperative spectrum sharing among a primary user and multiple secondary users, where the primary user selects a proper set of secondary users to serve as the cooperative relays for its transmission. In return, the primary user leases portion of channel access time to the selected secondary users for their own transmission.

The primary user decides the portion of channel access time it will leave for the selected secondary users (i.e., the cooperative relays), and the cooperative relays decide their power level used to help primary user's transmission in order to achieve proportional access time to the channel. We assume that the primary user and secondary users are rational and selfish, i.e., they only aim at maximizing their own utility. As secondary user's utility is in term of their own transmission rate and the power cost for primary user's transmission, so they will choose a proper power level to meet the tradeoff between transmission rate and power cost. Primary user will choose a proper portion of channel access time for the cooperative relays to attract them to employ higher power level. To tackle the problems in existing system, we first propose a distributed algorithm to find the solution of the developed matching game that result in a stable matching between the sets of the primary and secondary users. The use of Upper Confidence Bound (UCB) algorithms to build an efficient cognitive agent in order to tackle the DSA issue with perfect sensing. As a matter of fact, UCB based policies are known to offer a good solution to the exploration-exploitation trade-off.

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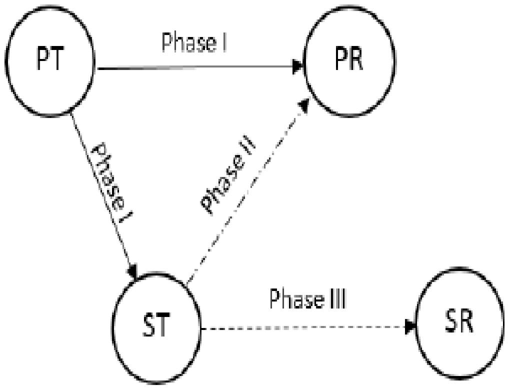

Fig.1.System Architecture

The general approach suggested by the UCB algorithms aims at selecting actions based on indexes that provide an optimistic evaluation on the rewards associated to the channels the secondary user can potentially exploit and we focus on cooperative spectrum sharing in a wireless network consisting of multiple primary and multiple secondary users. In particular, we study the partner-selection and resource-allocation problems within a matching theory framework, in which the primary and secondary users aim at optimizing their utilities in terms of transmission rate and power consumption. In our project, we propose distributed algorithm that is designed to run on computer hardware constructed from inter connected processors. Distributed algorithms are used in many varied application areas of distributed computing, such as telecommunications, scientific computing, distributed information processing, and real-time process control. This distributed algorithm helps to solve the matching game that yields a stable matching between the sets of primary and secondary users. The combination of these two algorithms makes a more efficient use of the available information, achieving a better performance without significantly increasing the computational overhead.

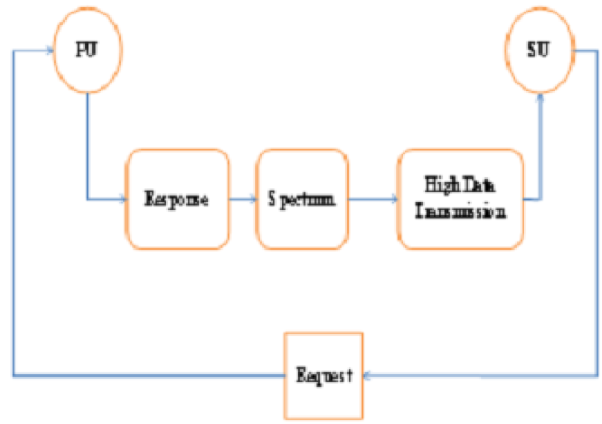

Fig 2.Block Diagram

- The unlicensed wireless users (Secondary users) access the licensed band from legacy spectrum holders (Primary users).
- The primary users are the spectrum's owner & the secondary users seek to obtain the transmission opportunities.
- Each Primary Transmitter (PT) can employ one Secondary Transmitter (ST) as a cooperative relay, this will improve the Quality of Service.
- Primary Transmitter shares spectrum with Secondary Transmitters.
- All the SUs are initially not associated to any PU. The SUs send their profile information including their Channel State Information and Pmax to the available PUs.
- Each SU selects its strategy (transmit power) according to the time allocation parameters for all the Pus.
- Each SU sends a request of cooperation to its most preferred PU.
- Among the SU applicants, the PU only keeps the list of SUs who are capable of offering a transmission rate higher than that of the direct path.
- Licensed users are the primary users and unlicensed users are the secondary users. Secondary user requests the primary user for some amount of spectrum. Primary user allocates the spectrum to the secondary users by itself without degrading its own performance using cooperative spectrum sharing techniques.

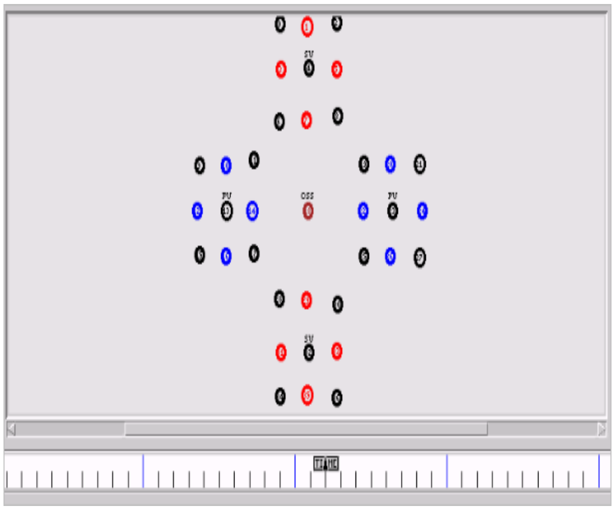

Fig.3Cooperative Spectrum Sharing

IV. CONCLUSION

We have proposed a spectrum trading mechanism in Cooperative Spectrum Sharing (CSS) allowing a primary transmitter (PT) to efficiently learn its most profitable action while maximizing its reward, defined as accumulated throughput. The learning strategy is based on a nested scheme that exploits the problem structure, and is capable of effectively handling an otherwise intractable problem, making use of Upper Confidence Bounds(UCB). We have focused on a scenario where the PT has no knowledge of the performance of the SUs acting as relays, or about the offers they are willing to accept. Using our proposed scheme, we developed two algorithms, Distributed algorithm and Super-UCB, which have been shown to be able to learn payoff maximizing actions for the PT with little communication or computation overhead. Our results indicate that, despite their simplicity, they significantly outperform the classical exploration-exploitation ϙ-greedy algorithm, with Super-UCB featuring a better overall performance. They are shown to be robust to inaccuracies in the little information they need and to scale well when the size of the problem increases, i.e., for more SUs and available offers. This work can be the starting point to address more complex scenarios. We extended our model to a more flexible bargaining scheme (MAB-multi MDP) and to a scenario with more dynamic SUs (MAB-MAB). Considering the explosion of MAB variants in the recent literature, interesting directions for future study include: 1) how to exploit the spatial fading correlation across different SUs, 2) extension of the algorithms to a multiple PT and multiple PR case, 3) inclusion of more dimensions to learning, such as learning the staying time of SUs in the PT coverage area, 4) inclusion of more complex SU and PU strategic behaviors, and 5) extension to different objectives such as energy efficiency of the transmission and/or quality of service constraints.

V. REFERENCES

[1] T. M. Valletti, "Spectrum trading," Telecommunications Policy, vol. 25, no. 10-11, pp. 655–670, Oct. 2001.

[2] E. A. Jorswieck, L. Badia, T. Fahldieck, E. Karipidis, and J. Luo, "Spectrum sharing improves the network efficiency for cellular operators," IEEE Commun. Mag., vol. 52, no. 3, pp. 129–136, Dec. 2013.

[3] Q. Zhao and B. Sadler, "A survey of dynamic spectrum access," IEEE Signal Process. Mag., vol. 24, no. 3, pp. 79–89, May 2007.

[4] M. López-Martínez, J. J. Alcaraz, J. Vales-Alonso, and J. Garcia- Haro, "Automated spectrum trading mechanisms: Understanding the big picture," Wireless Networks, vol. 21, no. 2, pp. 685–708, Jan. 2015.

[5] O. Simeone, I. Stanojev, S. Savazzi, U. Spagnolini, and R. Pickholtz, "Spectrum leasing to cooperating secondary ad hoc networks," IEEE J. Sel. Areas Commun., vol. 26, no. 1, pp. 203–213, Jan. 2008.

[6] J. Zhang and Q. Zhang, "Stackelberg game for utility-based cooperative cognitive radio networks," in Proceedings of the 10th ACM International Symposium on Mobile Ad Hoc Networking and Computing, (MobiHoc), 2009, pp. 23–31.

[7] G. Zhang, K. Yang, J. Song, and Y. Li, "Fair and efficient spectrum splitting for unlicensed secondary users in cooperative cognitive radio networks," Wireless Personal Communications, vol. 71, no. 1, pp. 299–316, Aug. 2012.

[8] P. Auer, N. Cesa-Bianchi, and P. Fischer, "Finite-time analysis of the multi armed bandit problem," Mach. Learn., vol. 47, no. 2-3, pp. 235–256, May 2002.

[9] X. Feng, G. Sun, X. Gan, F. Yang, and X. Tian, "Cooperative spectrum sharing in cognitive radio

networks: A distributed matching approach," IEEE Trans. Commun., vol. 62, no. 8, pp. 2651–2664, Aug. 2014.

[10] L. Duan, L. Gao, and J. Huang, "Cooperative spectrum sharing: A contract-based approach," IEEE Trans. Mobile Comput., vol. 13, no. 1, pp. 174–187, Jan. 2014.

[11] Y. Yan, J. Huang, and J. Wang, "Dynamic bargaining for relay based cooperative spectrum sharing," IEEE J. Sel. Areas Commun., vol. 31, no. 8, pp. 1480–1493, Aug. 2013.

[12] S. Jayaweera, M. Bkassiny, and K. Avery, "Asymmetric Cooperative Communications Based Spectrum Leasing via Auctions in Cognitive Radio Networks," IEEE Trans.Wireless Commun., vol. 10, no. 8, pp. 2716–2724, Aug. 2011.

[13] X. Feng, H.Wang, and X.Wang, "A game approach for cooperative spectrum sharing in cognitive radio networks: Spectrum sharing games among PUs and SUs," Wireless Communications and Mobile Computing, vol. 15, no. 3, pp. 538–551, Feb. 2015.

[14] Y. Yi, J. Zhang, Q. Zhang, T. Jiang, and J. Zhang, "Cooperative communication-aware spectrum leasing in cognitive radio networks," in IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), 2010, pp. 1–11.

[15] T. Nadkar, V. Thumar, G. Shenoy, A. Mehta, U. B. Desai, and S. N. Merchant, "A cross-layer framework for symbiotic relaying in cognitive radio networks," in IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), May 2011, pp. 498– 509.

[16] M. G. Adian and H. Aghaeinia, "An auction-based approach for spectrum leasing in cooperative cognitive radio networks: when to lease and how much to be leased," Wireless Networks, vol. 20, no. 3, pp. 411–422, Apr. 2014.

[17] A. T. Hoang and Y.-C. Liang, "Dynamic spectrum allocation with second-price auctions: When time is money," in International Conference on Cognitive Radio Oriented Wireless Networks and Communications. CrownCom, 2008, pp. 1–6.

[18] J. Huang, "Market mechanisms for cooperative spectrum trading with incomplete network information," IEEE Commun. Mag., vol. 51, no. 10, pp. 201–207, Oct. 2013.

[19] X. Yuan, Y. Shi, Y. T. Hou,W. Lou, and S. Kompella, "UPS: A united cooperative paradigm for primary and secondary networks," in IEEE 10th International Conference on Mobile Ad-Hoc and Sensor Systems, 2013, pp. 78–85.

[20] Y. Han, S. H. Ting, and A. Pandharipande, "Secondary user selection," IEEE Trans. Wireless Commun., vol. 9, no. 9, pp. 2914– 2923, Sep. 2010.

[21] D. Li, Y. Xu, X.Wang, and M. Guizani, "Coalitional game theoretic approach for secondary spectrum access in cooperative cognitive radio networks," IEEE Trans. Wireless Commun., vol. 10, no. 3, pp. 844–856, Mar. 2011.

[22] D. Niyato and E. Hossain, "Market-equilibrium, competitive, and cooperative pricing for spectrum sharing in cognitive radio networks: Analysis and comparison," IEEE Trans. Wireless Commun., vol. 7, no. 11, pp. 4273–4283, Nov. 2008.